

Lesson 14:

Rotating a 2D Shape

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Standards

This lesson is focused on visualizing relationships between two-dimensional and three-dimensional objects, specifically the latter part of this standard:

[CCSS.Math.Content.HSG.GMD.B.4](#)

"Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects."

Note that the first part of this standard is covered by Lesson 7.

Objectives

- Be able to predict the 3D shape that will be generated when a 2D shape is rotated about an axis
- Be able to describe how the 3D generated shape will change if the 2D shape is rotated about a different axis before rotation.

Models Used

You can find the model for this Lesson at <https://github.com/whosawhatsis/Geometry>. See the Teacher's Guide for how to use Github.

- revolution.scad
 - This model allows you to rotate different 2D shapes to make 3D ones.
- You will also need:
 - Some jumbo (2-inch) paperclips, or wire of similar strength and diameter; or an extra length of 3D printer filament

2D to 3D

In Lesson 7, we saw that you can cut through a 3D model at various angles to get interesting 2D cross-sections. In this Lesson we check out a related process. If we take a 2D shape and spin it around, what sort of 3D shape will it create? As we will see, the answer depends both on the initial shape, and on the imaginary axis you select to spin the 2D shape. For example, a square spun around an axis that passes through two of its corners generates a different shape than if you spin it around an axis that is parallel to one of its sides.

The Model

The model creates a thin, hollowed-out version of the 2D shape to be rotated that fits around the 3D solid. Note that this process only really makes sense if you are rotating an object that is symmetrical around the axis of rotation. If it isn't, the program overlays a mirror of the first side over the second and rotates around the result. (For example, if you had a figure that was a circle on the left of the axis of rotation and a square on the right, such that the circle would be inscribed in the square, you would get the same result as rotating the square.)

It has a few settings that apply regardless of what 2D shape you are rotating about an axis (all in mm).

- `wall = 4;`
 - width of 2D shape
- `thick = 4;`
 - thickness of 2D shape
- `hole = 2;`
 - size of hole in 3D shape for pivot
- `clearance = .3;`
 - clearance between 2D and 3D shape

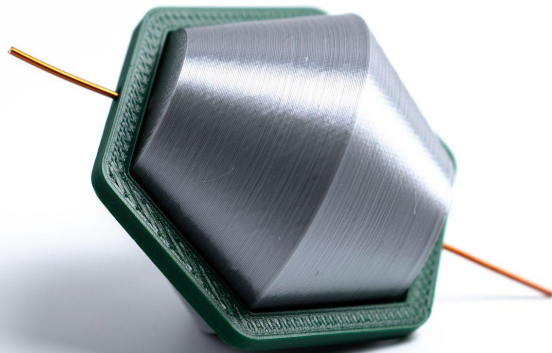
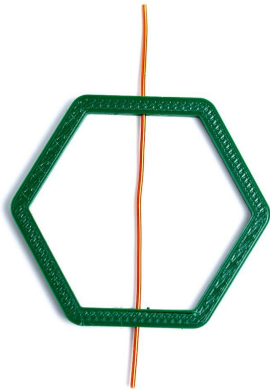
Each model that we show here is the result of uncommenting one line in the program. That means that there is a long list of descriptions of possible models to print, followed by a line of OpenSCAD. When you remove the `//` before the relevant line of OpenSCAD (and only one line from the list) the relevant model will print. The following list gives the description of the options currently built into the program, the line of OpenSCAD you want to uncomment, and a photo.

To assemble each model, either run a piece of 3D printer filament, wire, unbent paperclip etc through the holes in the external and external figures. If you use a paperclip which will have sharp ends, you'll want to bend it around the outside of the figure, like a handle. Our examples show using a piece of 1.75 mm filament. You might have to experiment with the value of the variable *hole* for things to work well.

Hexagon

Create a shape from a hexagon rotated about line through vertices:

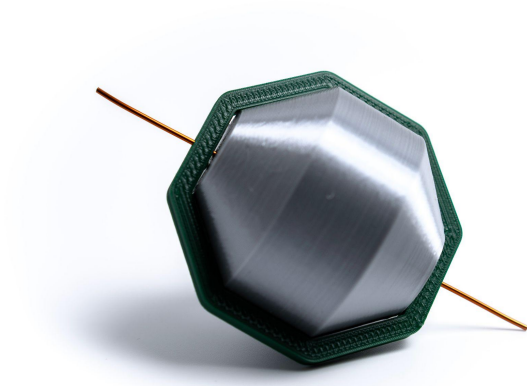
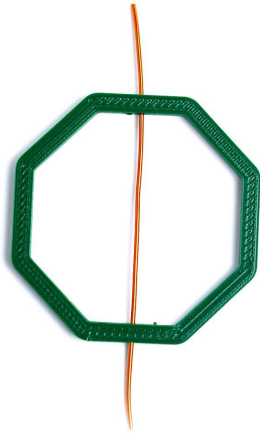
```
module shape() translate([0, 25 * cos(180 / 6), 0]) rotate(0) circle(r = 25, $fn = 6);
```



Octagon

Create a shape from an octagon rotated about a line parallel to a side:

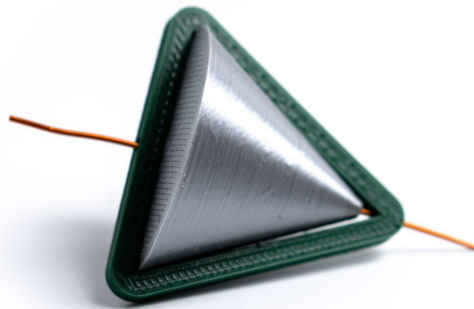
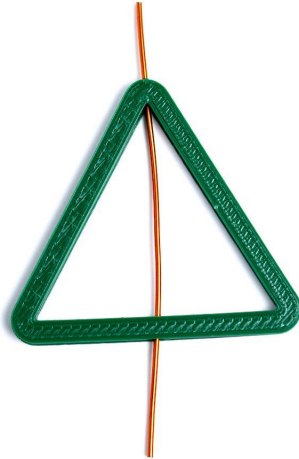
```
//module shape() translate([0, 25 * cos(180 / 8), 0]) rotate(180 / 8) circle(r = 25, $fn = 8);
```



Triangle

Create a shape from a triangle, rotated about a line through one of its vertices.

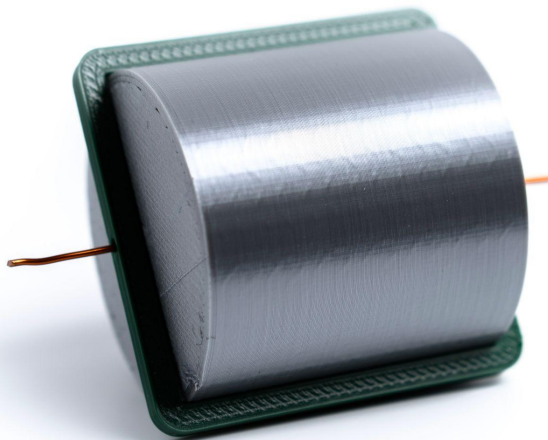
```
module shape() translate([0, 25 * cos(180 / 3), 0]) rotate(-30) circle(r = 25, $fn = 3);
```



Square

First, you can create a cylinder from a square rotated about a line parallel to a side:

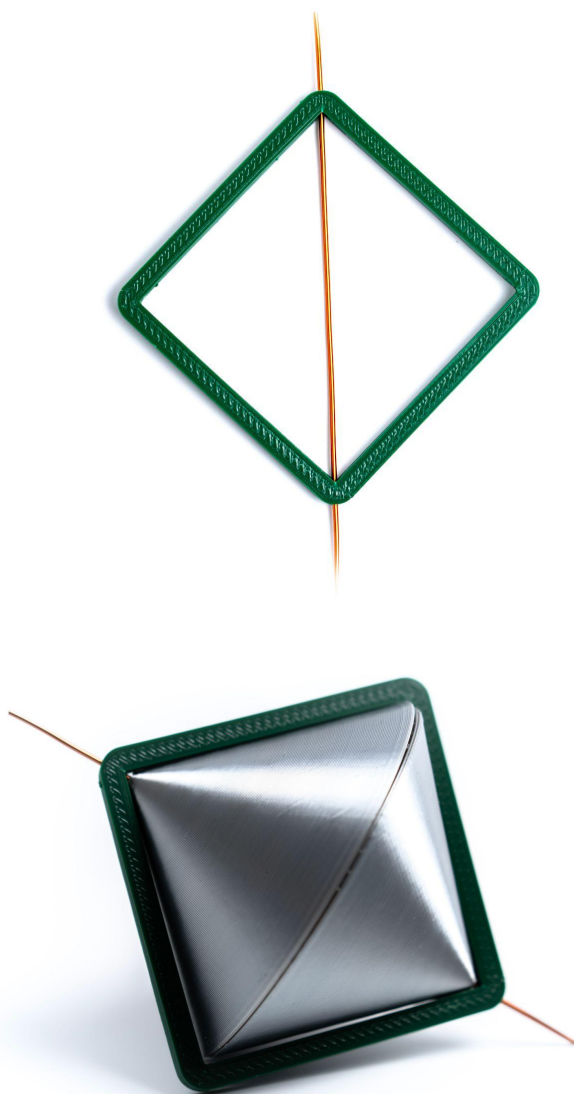
```
module shape() translate([0, 25, 0]) rotate(0) square(50, center = true);
```



Next, let's rotate the same square around a line through one of its vertices, rather than a line parallel to a side. This will create a double cone from a square rotated about a diagonal.

```
module shape() rotate(45) square(50, center = true);
```

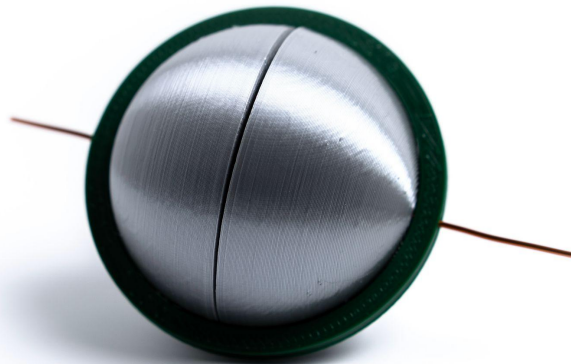
To avoid needing to create (and remove) support material, some of these 3D figures will print in two pieces. They are designed so that you can run a wire through the center of both halves of the piece and hold them together. The model decides to do this or not without your intervention. For example, if we rotate a square about its diagonal, we get a double cone that would be challenging to print. Splitting it into two cones makes it much simpler to print. You might want to allow a bit more clearance though in case your prints warp a little on the bottom.



Sphere

Create a sphere from a circle rotated about a diameter (Note: makes 2 hemispheres that need to be assembled)

```
module shape() circle (25);
```



Be Careful Scaling These Models

If you elect to scale these models, you will need to be careful. Make sure that you are scaling consistently in all three dimensions if you are scaling in your slicing program, and be aware that the small hole for the axis will be scaled as well. You might need to do some trial and error

testing to create models beyond the ones listed here for you. And, of course, if you scale, be sure that the hole is big enough for whatever you are using as a pivot.

Assessments

Explore each of the models with its 2D and associated 3D shape. Speculate on how the surface might change if you altered the axis of rotation of the 2D shape. For example, what might happen if you rotated a square about one of its sides, instead of the middle and diagonal like we do here?

If You Don't Have a 3D Printer

As always, a public library or makerspace might be able to create this model for you if you have no access to a printer yourself. Failing that, for the simpler shapes, you might think about using styrofoam to make the 3D shapes, and then cut out the 3D generating shape from cardboard.

Where to read more

- When you move on to calculus, you will learn about sweeping a curve about an axis, which is a similar process. Surfaces created that way are called solids of revolution, [Solids of Revolution \(Wikipedia\)](#).
- For the big picture on geometry: [Geometry \(Wikipedia\)](#)